

BBCX



REPORT

on

WATER QUALITY

in

BALA BAY & DARK LAKE

1971

RECREATIONAL LAKES PROGRAM

Copyright Provisions and Restrictions on Copying:

This Ontario Ministry of the Environment work is protected by Crown copyright (unless otherwise indicated), which is held by the Queen's Printer for Ontario. It may be reproduced for non-commercial purposes if credit is given and Crown copyright is acknowledged.

It may not be reproduced, in all or in part, for any commercial purpose except under a licence from the Queen's Printer for Ontario.

For information on reproducing Government of Ontario works, please contact ServiceOntario Publications at copyright@ontario.ca

BBCX

16-04-1997
PDB library

THE
ONTARIO WATER RESOURCES COMMISSION
REPORT
ON WATER QUALITY
IN
DARK LAKE AND BALA BAY
1971

GENERAL TABLE OF CONTENTS

LIST OF FIGURES.....	ii
LIST OF TABLES.....	iii
SUMMARY.....	iv
INTRODUCTION.....	1
AREA DESCRIPTION.....	3
FIELD AND LABORATORY METHODS	
Physical, Chemical and Biological Field Methods.....	7
Physical, Chemical and Biological Laboratory Methods.....	7
Bacteriological Field and Laboratory Methods.....	8
Bacteriological Statistical Methods.....	9
DISCUSSION OF RESULTS	
Temperature and Dissolved Oxygen.....	12
pH, Total Alkalinity and Free Carbon Dioxide.....	12
Hardness, Chloride, Conductivity and Iron.....	14
Kjeldahl Nitrogen and Total Phosphorus.....	14
Chlorophyll <u>a</u>	14
Sediment Diatom Analyses.....	16
Bacteriology.....	17
TABLES.....	22
EXPLANATION OF TERMS IN BACTERIOLOGICAL TABLES.....	25
GLOSSARY.....	29
BIBLIOGRAPHY.....	33

LIST OF FIGURES

Figure 1	Map of Dark Lake and Bala Bay showing shoreline development and topography.....	4
Figure 2	Temperature and dissolved oxygen profiles (a) in Dark Lake, Station 15 on October 10, 1971 and (b) in Bala Bay, Station 9 on October 13, 1971...	13
Figure 3	The relationship between chlorophyll <u>a</u> and Secchi disc as determined from the recreational lakes surveyed in 1971 as well as the individual chlorophyll <u>a</u> and Secchi disc values for Dark Lake and Bala Bay.....	15
Figure 4	Bacterial densities in May, 1971.....	18
Figure 5	Bacterial densities in August, 1971.....	19
Figure 6	Bacterial densities in October, 1971.....	20

LIST OF TABLES

Table 1	Chlorophyll <u>a</u> and Secchi disc values for Dark Lake and Bala Bay during 1971.....	22
Table 2	The Araphidinae/Centrales ratio of the surface sediment samples collected from Dark Lake, station 15 and Bala Bay, station 9 in 1971.....	23
Table 3	Results for Iron, Hardness, Total Phosphorus, Kjeldahl Nitrogen, Chloride and Conductivity in Dark Lake and Bala Bay in 1971.....	24
Table 4	Summary of the Analysis of Variance Grouping of Stations for Total Coliforms per 100 ml.....	26
Table 5	Summary of the Analysis of Variance Grouping of Stations for Fecal Coliforms per 100 ml.....	27
Table 6	Summary of the Analysis of Variance Grouping of Stations for Fecal Streptococci per 100 ml.....	28

SUMMARY

A study to evaluate the status of water quality in Dark Lake and Bala Bay was carried out during the summer of 1971.

Dark Lake and Bala Bay lie within the Precambrian Shield. The area is characterized by rolling hills, good local drainage and shallow overburden covering Precambrian bedrock. The shoreline is covered with a variety of top soils ranging from fine sandy loams to coarse granitic loamy sands. Rock outcrop dominates most of the shoreline. Generally, the soil cover is less than the five feet required by the Department of the Environment for the installation of a septic tank system.

Thermal stratification was observed in both Dark Lake and Bala Bay. In Dark Lake a severe metalimnetic oxygen decrease was evident with a total absence of oxygen in the bottom waters. Bala Bay had an oxygen reduction through the metalimnion but no severe hypolimnetic decrease.

The chemical water quality was characteristic of soft water Precambrian lakes. The use of detergents containing phosphates is not necessary in such soft water and should be avoided by area residents.

Chlorophyll a concentrations were low to moderate in Dark Lake and low in Bala Bay and reflected low to moderate productive capacities. An analysis of diatoms in surface sediments of both Dark Lake and Bala Bay indicated the oligotrophic character of the waters.

Dark Lake and Bala Bay were well within the OWRC bacteriological criteria for total body contact recreational use during all three surveys. The overall geometric means for most of the stations were 10 TC/100, 2 FC/100 ml and 1 FS/100 ml in May, 20 TC/100 ml, 2 FC/100 ml, and 3 FS/100 ml in August, and 24 TC/100 ml, 1 FC/100 ml and 2 FS/100 ml, in October.

In order to maintain the existing water quality every effort should be made to ensure that direct flow or leachate from domestic waste disposal systems or other potential sources of pollution do not gain access to the lake.

INTRODUCTION

Maintenance of good water quality in recreational lakes in the Province of Ontario is of vital concern to the Ontario Water Resources Commission, the Ontario Department of the Environment and other governmental agencies involved in tourism and the control and management of shoreline development of cottages and resorts. In 1970 an interdepartmental program was established to survey a number of recreational lakes in order to detect and correct sources of water pollution and ensure that our lakes would be well managed to protect water quality. The Ontario Department of Health, whose jurisdiction in this program was transferred to the Department of the Environment in December 1971, would carry out on-shore inspection and correction of faulty private waste disposal systems, whereas the Ontario Water Resources Commission would evaluate the existing water quality of the respective lakes. A record of the present status of the private waste disposal systems and the lake water quality would also be documented for comparative use in any future studies.

Recreational lakes are subjected to two major types of water quality impairment; bacteriological contamination and excessive growths of algae and aquatic weeds (eutrophication). The two problems may result from a common source of wastes but the consequences of each are quite different. Bacteriological contamination by raw or inadequately treated sewage poses an immediate public health hazard if the water is used for bathing. In order for this to occur, raw wastes or septic tank effluents must gain entry to the lake although it may not be obvious upon visual inspection of the site. It must be noted that no surface water is considered safe for human consumption without prior treatment including disinfection. The algae and weed problems which have come into prominence in recent years are caused by plant nutrients being added to the lake. Excessive algae and weed growths impair aesthetic values and recreational use of a lake but seldom pose a health hazard. There are nutrient sources other than sewage wastes which do not create serious bacterial hazards but do support nuisance plant growths such as agricultural fertilizer losses and normal nutrient runoff from forest and field.

In order to carry out its responsibility of evaluating the status of water quality in recreational lakes, the Ontario Water Resources Commission undertook a study on Dark Lake and Bala Bay in the summer of 1971. Three surveys were conducted; a spring survey from May 21 to 25, a mid-summer survey from August 26 to 30 and a fall survey from October 10 to 14 inclusive. These studies included the assessment of bacteriological, physical, chemical and biological conditions of the lake with stress being placed on the bacteriological and nutrient enrichment problems.

Sampling surveys were conducted on an intensive basis (sampling each day for a minimum of five days) which is mandatory for a reliable assessment of bacteriological conditions.

In addition to the results obtained from these studies, information from other governmental agencies has been incorporated in this report which is the Ontario Water Resources Commission's contribution to the Interdepartmental Task Force Report which will deal with the overall cottage pollution control program in Ontario.

AREA DESCRIPTION

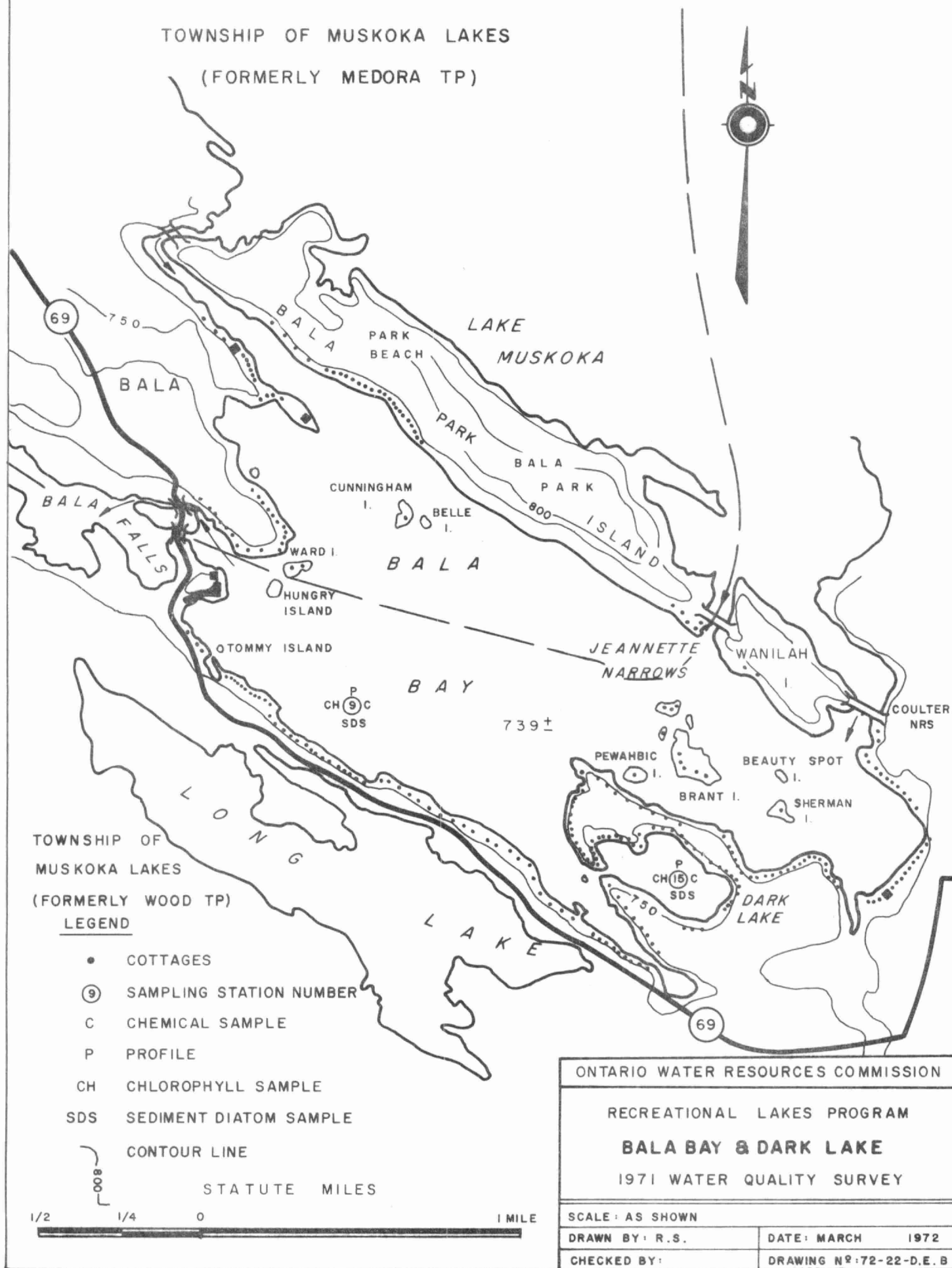
Geography and Topography

Dark Lake and Bala Bay are located in the Township of Muskoka Lakes, District Municipality of Muskoka and are approximately 32 kilometers (20 miles) north-west of the Town of Gravenhurst. Dark Lake is a small round bay, contained within the Point Manchee peninsula at the east end of Bala Bay. There is a small channel joining Dark Lake and Bala Bay at the mid-point of the peninsula's south shore. Bala Bay lies in the south-west section of Lake Muskoka, separated from it by Wanilah and Bala Park islands, which make up its north shore. Bala Bay is rectangular in shape with a peninsula at both ends (the community of Bala at the west end and Point Manchee at the east end) forming four bays. (Figure 1)

Dark Lake has a surface area of 10 hectares (24 acres), a shoreline length of 1 kilometer (0.6 miles), and a maximum depth of 12 meters (38 feet). Bala Bay has a surface area of 4 square kilometers (1,070 acres), a shoreline length of 14 kilometers (10 miles), and a maximum depth of 37 meters (122 feet). Both bodies of water have steep sloping bottoms along their north and south shores which flatten out towards the middle.

The Dark Lake and Bala Bay watershed covers 8 square kilometers (1,900 acres) of land dominated by rolling hills. The soil belongs to the Monteagle series except for a small area of land at the north-east tip of the bay, which belongs to the Wendigo series. The Monteagle series is found within the Precambrian Shield and is comprised of a granitic sandy loam glacial till with a Podzol profile and good drainage. Rock outcrop is frequent and the soil cover is thin and excessively stony. The soil of the Wendigo series is a granitic loamy sand with a Podzol profile and good drainage. It consists almost entirely of a medium sized sand and is stone free.

FIGURE 1



In many instances, the soil cover surrounding Dark Lake and Bala Bay is less than the 1.5m (5 feet) required by the Department of the Environment for the installation of a septic tank system.

Climatic Range

The area has a mean daily temperature of -9°C (15°F) in January and a mean temperature of 19°C (66°F) in July. The mean annual precipitation is 1 meter (40 inches) including 3 meters (116 inches) of snow. According to meteorological records, the area enjoys about 200 days that have no measurable precipitation. The summer climate is conducive to most recreational activities and the winter with its abundance of snow early in the season, provides for participation in most winter sports.

Water Movement

Dark Lake and Bala Bay lie in the Georgian Bay Terminal Drainage Basin. Dark Lake has no inlets or outlets other than the channel joining it to Bala Bay. Bala Bay has four separate inlets. Three of them are from Lake Muskoka: Wallace Cut at the west tip of Bala Park Island, Jeannette Narrows between Bala Park and Wanilah Island and Coulter Narrows at the east tip of Wanilah Island. The fourth inlet is Brandy Creek at the north-east tip of Bala Bay coming from Resound Lake. The only outlet from Bala Bay is at the south-west end where three dams control the flow into the Muskoka River. The three dams are owned and operated by the Department of Lands and Forests.

Shoreline Development

The shorelines of Dark Lake and Bala Bay are generally well developed except for the south shore of Dark Lake and the east half of Bala Park Island. The area around the communities of Bala and Torrance are densely developed with permanent and summer vacation homes. There are approximately 35 cottages on Dark Lake and 215 cottages and 4 lodges along the shores of Bala Bay. (Figure 1)

Water Usage

The majority of the cottage owners and the community of Bala use the lake as their source of domestic water supply. The lake supports recreational water sports such as fishing, boating, water skiing and swimming. According to information available from the Department of Lands and Forests the most common fish in the two lakes are lake trout, rainbow trout, whitefish, smelt, small mouth bass, yellow perch and various forage species.

The nearest municipal refuse disposal site is approximately 1 kilometer (0.6 miles) north-west of Bala on concession C, lot 14 in the Township of Muskoka Lakes (Medora). The community of Bala has its sewage treatment plant located outside the town on concession VII, lot 34 in the Township of Muskoka Lakes (Wood). The effluent flows into Long Lake which is south of Bala Bay. Normally there is no flow from Long Lake to Bala Bay, however there is some flow during spring runoff via a culvert under Highway 69.

FIELD AND LABORATORY METHODS

Physical, Chemical and Biological Field Methods

Physical, chemical and biological water quality surveys were conducted from May 21 to 25, August 26 to 30 and October 11 to 14 on Dark Lake and Bala Bay. Six near-shore stations (4, 12, 22, 24, 25 and 30) and two mid-lake Stations (9 and 15), were selected for chemical and biological sampling. The near-shore stations were close to inlets and outlets.

At mid-lake stations dissolved oxygen and temperature profiles were determined daily in the field using a combination dissolved oxygen-telethermometer unit. Total alkalinity and free carbon dioxide were measured daily titrimetrically, and pH was measured with a portable pH meter. Daily chlorophyll samples were collected in a 32-ounce bottle, at each mid-lake station, utilizing a composite sampler lowered through the euphotic zone (2X Secchi disc) and immediately preserved with 10 - 15 drops of 2% MgCO_3 .

At least once, a 32-ounce sample for hardness, alkalinity, chloride, total phosphorus, total Kjeldahl nitrogen, iron and conductivity was collected at all mid-lake stations as well as at the major inlets and outlets. The mid-lake stations were sampled using a composite sampler through the euphotic zone. At inlets and outlets, samples were collected from 1 meter of depth using a Kemmerer sampler.

Three sediment cores for diatom frustule examination were collected from both station 9 and 15, during the autumn of 1971. From the surface of each sediment core three sub-samples were removed for laboratory enumeration to species.

Physical, Chemical and Biological Laboratory Methods

All analyses were carried out using routine OWRC methods based on Standard Methods 13th Edition.

Iron was measured after the sample had been digested with acid to dissolve all forms of iron present.

Kjeldahl nitrogen and total phosphorus were determined after the sample was digested with acid and an oxidizing agent to destroy organic matter.

For chlorophyll determinations, 1 liter samples were filtered through a 1.2 μ membrane filter which was then extracted with 90% acetone for 24 hours. Absorbance of the extract was determined at wavelengths 600 to 750 m μ using a Unicam SP1800 ultra violet spectrophotometer. The concentrations of chlorophyll a were calculated using the equation given by Richards and Thompson (1952).

Bacteriological Field and Laboratory Methods

Five day intensive bacteriological surveys were completed on Dark Lake and Bala Bay during May, August and October. Thirty stations were sampled each day at a depth of 1 meter below the surface using sterile, autoclavable polycarbonate 250 ml bottles. Additional samples were collected at Stations 15D and 26D (Figure 4) one meter above the bottom using a modified "piggy-back" sampler and sterile 237 ml evacuated rubber air syringes. All samples were stored on ice and delivered to the mobile laboratory within two to six hours and analyzed for total coliforms, fecal coliforms and fecal streptococcus using the membrane filtration technique (MF) (Standard Methods 13 Edition) except that m-Endo Agar Less (Difco) was used for total coliform and MacConkey membrane broth (Oxoid) was used for fecal coliform determinations. The total coliforms (TC) fecal coliforms (FC) and fecal streptococcus (FS) were used as "indicators" of fecal pollution. These "indicators" are the normal flora of the large intestine, and are present in large numbers in the feces of man and animals. When water is polluted with fecal material, there is a potential danger that pathogens or disease causing micro-organisms may also be present.

The coliform group is defined, according to Standard Methods 13th Edition, as "all of the aerobic and facultative anaerobic, gram-negative, non-sporeforming rod-shaped bacteria which ferment lactose with gas formation within 48 hours at 35°C" and, or "all organisms which produce a colony with a golden green metallic sheen within 24 hours of incubation" using the MF technique. This definition includes, in addition to the intestinal forms of the Escherichia coli group, closely related bacteria of the genera Citrobacter and Enterobacter. The Enterobacter - Citrobacter groups are common in soil, but are also recovered in feces in small numbers and their presence in water may indicate soil runoff or, more important, less recent fecal pollution since these organisms tend to survive longer in water than do members of the Escherichia group, and even to multiply when suitable environmental conditions exist. A more specific test for coliforms of intestinal origin is the fecal coliform test, with incubation of the organisms at 44.5°C. Though by no means completely selective for Escherichia coli, this test has proved useful as an indicator of recent fecal pollution.

Fecal streptococci (or enterococci) are also valuable indicators of recent fecal pollution. These organisms are large, ovoid gram-positive bacteria, occurring in chains. They are normal inhabitants of the large intestine of man and animals, and they generally do not multiply outside the body. In waters polluted with fecal material, fecal streptococci are usually found along with coliform bacteria, but in smaller numbers, although in some waters they may be found alone. Their presence, along with coliforms, indicates that at least a portion of the coliforms in the sample are of fecal origin.

Bacteriological Statistical Methods

Fluctuations in bacterial concentrations due to changing environmental conditions require that a great number of samples be taken to arrive at a mean value which is

representative of a specific sample location or sampling area. The most appropriate mean for bacterial numbers and this type of data is the geometric mean. The vast quantities of bacteriological data generated from these samples necessitated the development of additional statistical methods to summarize the mean results into a more concise presentation. The statistical methods used are based on the analysis of variance. The stations on a lake can be grouped by this method, into areas or groups of stations with the same statistical bacterial level, without the bias normally associated with manual interpretation.

The analysis of variance is particularly effective where bacterial concentrations vary slightly throughout the lake. Areas or stations with slight differences in bacterial concentration can be isolated. Areas or stations with statistically higher bacterial numbers generally indicate an input.

The results from all the analyses were organized as replicates representing the stations during the survey period. All data were transformed to logarithms (base 10) and all further analyses were done using these transformed data. A geometric mean (the antilogarithm of the average of the logarithm) was calculated on each station and for each parameter. The validity of the analyses of variance program (ANOVA-CRE: Burger, 1972), was based on the assumptions that the variances of all the stations were similar (Bartlett's test of Homogeneity) and that the data were normally distributed. Both these assumptions were checked on Dark Lake and Bala Bay. The Bartlett's test was found to be non-significant and the data followed a normal distribution, so the analysis of variance (F-test; Sokal, 1969) was calculated in all the stations. If the F was significant, then the multiple-t test was used to help determine the stations which should be deleted from the overall group to yield a homogeneous group of stations. The withdrawn stations were regrouped with respect to geographic proximity and similar means. The calculations on all groups were

repeated using the analysis of variance program until each discrete group was homogeneous. The homogeneous groups that were geographically isolated were compared by means of the Student-t test (using the log GM and S.E.) which indicated the statistical difference between these groups. The Student-t test was also used to compare the grouped bacteriological data for the three surveys.

DISCUSSION OF RESULTS

Temperature and Dissolved Oxygen

At Station 15 in Dark Lake, a thermocline was located between 7 and 10m during October (Figure 2a). A severe metalimnetic decrease of dissolved oxygen was evident with a total absence in the bottom waters. The hypolimnetic deficit of oxygen results from bacterial oxidation of organic material, biological respiration and chemical oxidation of organic matter.

During the October survey, the thermocline at Station 9 (Bala Bay) was thin, being located between the 13 and 15m depths (Figure 2b). An oxygen reduction was apparent through the metalimnion but no severe hypolimnetic decrease was evident.

pH, Total Alkalinity and Free Carbon Dioxide

Surface pH values in Dark Lake and Bala Bay were slightly acidic, being consistent with soft-water Precambrian lakes. In the surface waters, the pH was generally higher than that of the bottom waters. Specifically, on August 26 at Station 15, values at 1 and 10m were 6.9 and 5.6 respectively. Free carbon dioxide and total alkalinity concentrations were usually higher in the hypolimnion than in the warmer surface waters. For example, on August 27 at station 9, free carbon dioxide concentrations at 1 and 30m were 2.0 and 11.3 mg/l respectively. Corresponding alkalinity values were 5.1 and 6.7 mg/l. Reduced pH values in the bottom waters are due to the accumulation of carbon dioxide derived from organic decomposition while the increased alkalinity is related to the release of bicarbonate from sediments by bacterial and chemical action in conjunction with calcium, magnesium, iron, manganese and ammonia.

Figure 2a

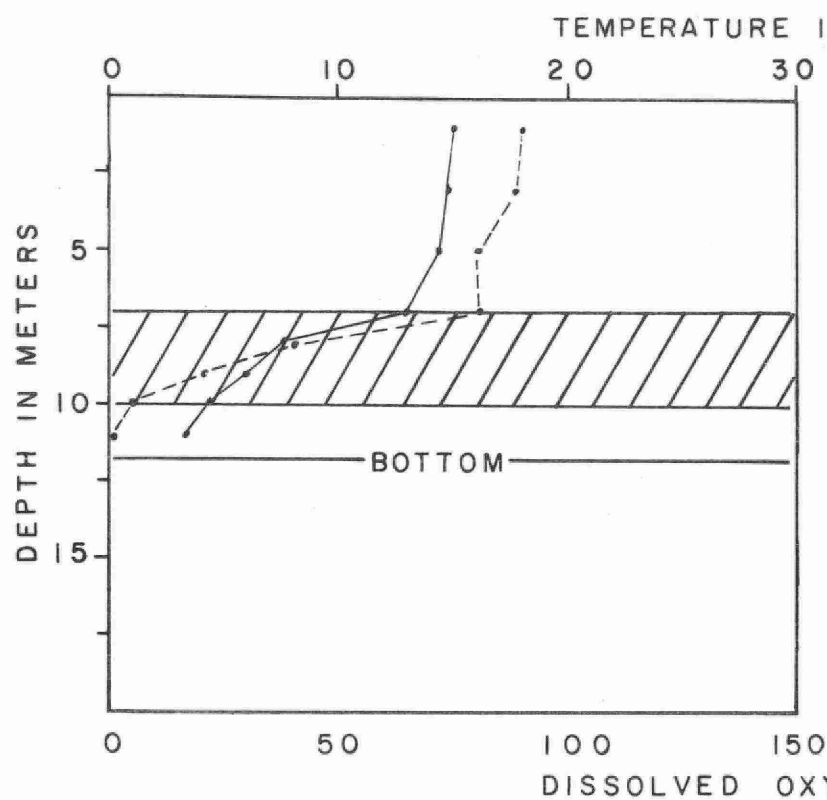
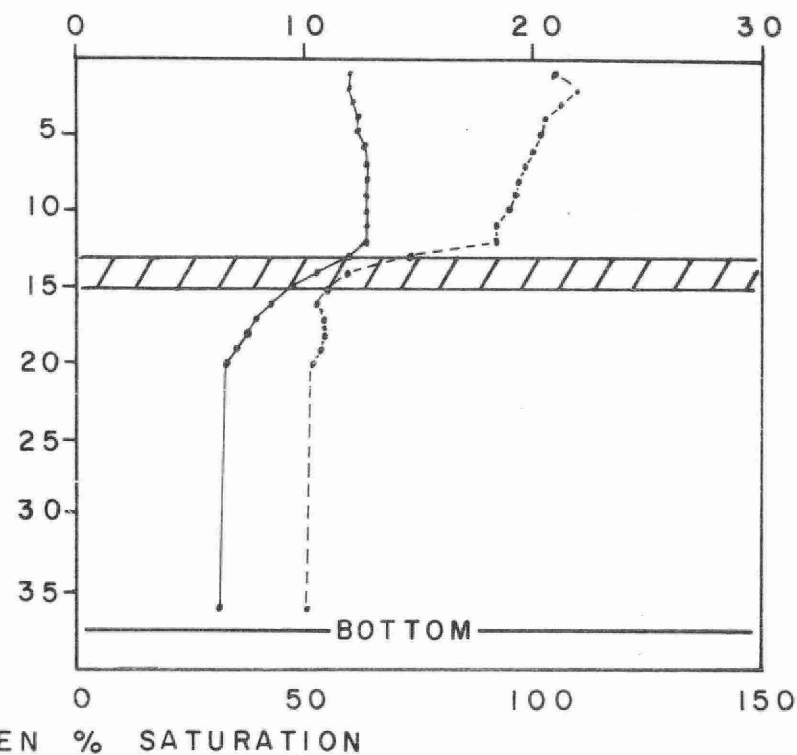


Figure 2b



— Temperature
 --- Dissolved Oxygen

Figure 2: Temperature and dissolved oxygen profiles (a) in Dark Lake, Station 15 on October 10, 1971 and (b) in Pala Bay, station 9 on October 13, 1971. The shaded areas approximate the position of the thermocline.

Hardness, Chloride, Conductivity and Iron

The values (Table 1) are normal for soft-water Precambrian lakes and are consistent with each other confirming that no unusual mineral characteristics were present. Detergents containing phosphorus are unnecessary in such soft water and their use should be avoided by area residents.

Kjeldahl Nitrogen and Total Phosphorus

Kjeldahl nitrogen and total phosphorus concentrations (Table 1) were generally low and would not be expected to cause any algal problems.

In Dark Lake, phosphorus concentrations in May and August were slightly higher than during the September survey and corresponds to higher chlorophyll a concentrations.

The sample taken at station 9 on May 23 had very high phosphorus, nitrogen and iron concentrations.

Chlorophyll a

The chlorophyll a concentrations and Secchi disc values for Dark Lake, Station 15, were 0.9 to 2.0 $\mu\text{g/l}$, 3.2 to 4.6 $\mu\text{g/l}$ and 2.8 to 3.7 $\mu\text{g/l}$ for the May, August and October surveys respectively (Table 2). Corresponding values for Bala Bay, Station 9 ranged from 0.8 to 1.6 $\mu\text{g/l}$, 1.1 to 1.9 $\mu\text{g/l}$ and 1.9 to 2.3 $\mu\text{g/l}$. The values for Bala Bay reflect extremely low algal populations, while those for Dark Lake reflect low to moderate populations.

Water clarity which is one of the more important parameters used in defining water quality, can be measured using a Secchi disc. Figure 3 presents a chlorophyll a - Secchi disc relationship for a number of surface waters and clarifies the

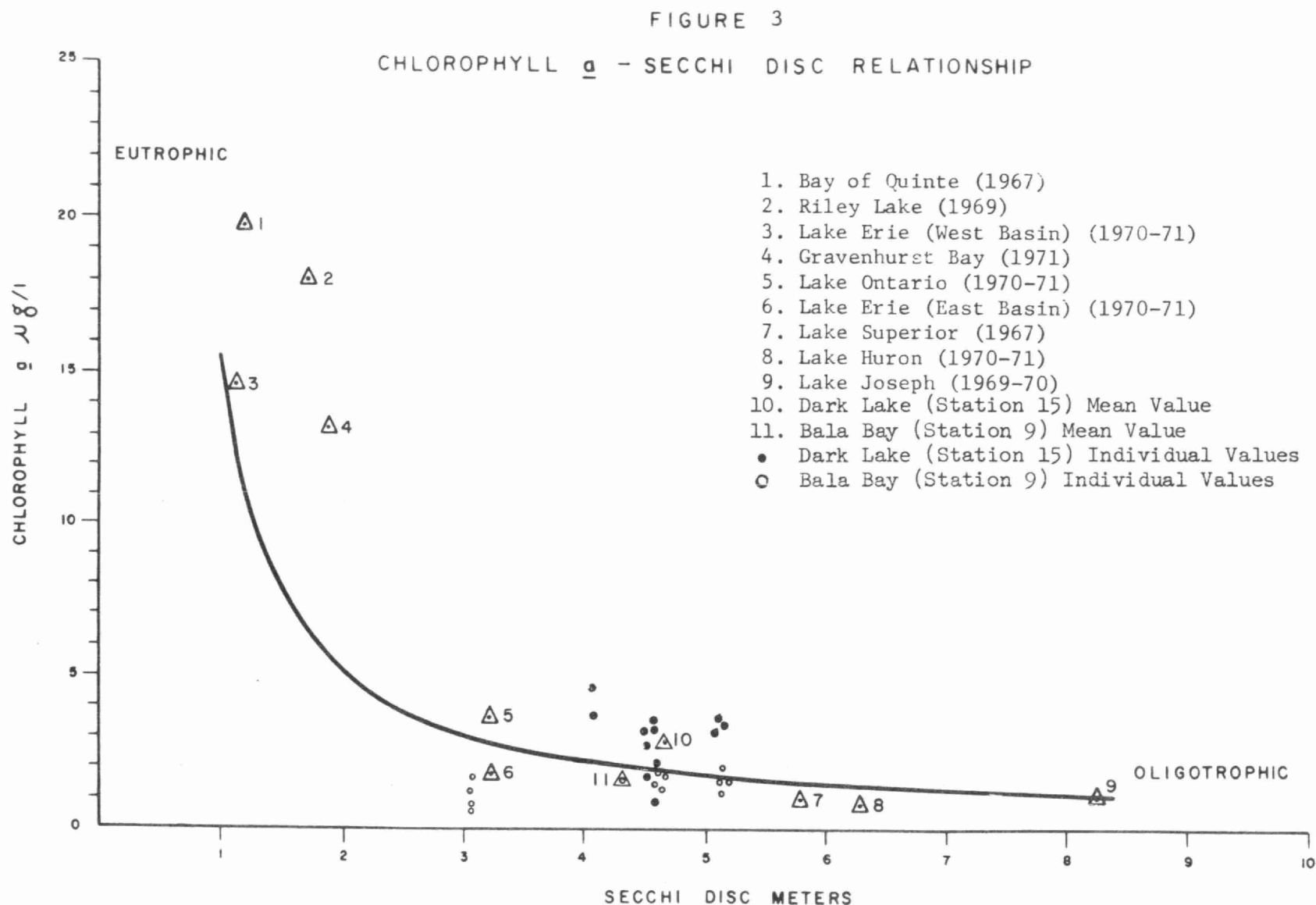


Figure 3: The relationship between chlorophyll a and Secchi disc as determined from the recreational lakes surveyed in 1971 as well as the individual chlorophyll a - Secchi disc values for Dark Lake (Station 15) and Bala Bay (Station 9). The Great Lake values were added for comparative purposes.

"trophic status" of Bala Bay and Dark Lake in relation to numerous other well known recreational lakes in the Province (see Brown 1972 for derivation of chlorophyll a - Secchi disc relationships). With respect to Figure 3, Dark Lake and Bala Bay are positioned between values observed for the oligotrophic lakes Superior and Huron and the more mesotrophic Lake Ontario and Eastern Basin of Lake Erie. The lake was well removed from the Bay of Quinte, Gravenhurst Bay and Riley Lake, three extremely enriched bodies of water.

Sediment Diatom Analyses

A good deal may be learned about the developmental history of a lake by studying the distribution and succession of diatoms in lake sediments. The frustules are well preserved under most limnological conditions and due to their specific gravity, sink to the bottom and remain in the sediments. Therefore, the sediment sample extracted from the upper one centimetre of the core sample contains diatoms representative of the recent trophic status of a lake.

Using a ratio of diatom groups, Araphidinae to Centrales (A/C) in lake sediments, Stockner (1971), developed a technique which classifies the trophic status in a number of soft water lakes in north-west Ontario and postulated the following broad trophic distinctions for lakes:

<u>Type</u>	<u>Ratio</u>
Oligotrophic	0 - 1.0
Mesotrophic	1.0 - 2.0
Eutrophic	> 2.0

To classify Dark Lake and Bala Bay, triplicate analyses on three sediment cores collected from both Stations 15

and 9 were quantitatively and qualitatively examined. The enumeration revealed mean A/C ratios of 0.477, 0.430 and 0.487 for station 15 and A/C ratios of 0.833, 0.863 and 0.413 for station 9 (Table 3). The values indicate that both lake areas contain planktonic diatom populations characteristic of oligotrophic lakes.

Bacteriology

Dark Lake and Bala Bay were well within the OWRC criteria for total body contact recreational use (OWRC, 1970) during all three surveys.

In May, the majority of stations on Dark Lake and Bala Bay had geometric mean bacterial levels of 10 TC/100 ml, 2 FC/100 ml and 1 FS/100 ml (Figure 4).

Stations 9, 15D, 20 and 26D had statistically lower TC levels than the rest of the lake (Table 4). Stations 15 and 17 had slightly higher FS levels of 2/100 ml (Table 6).

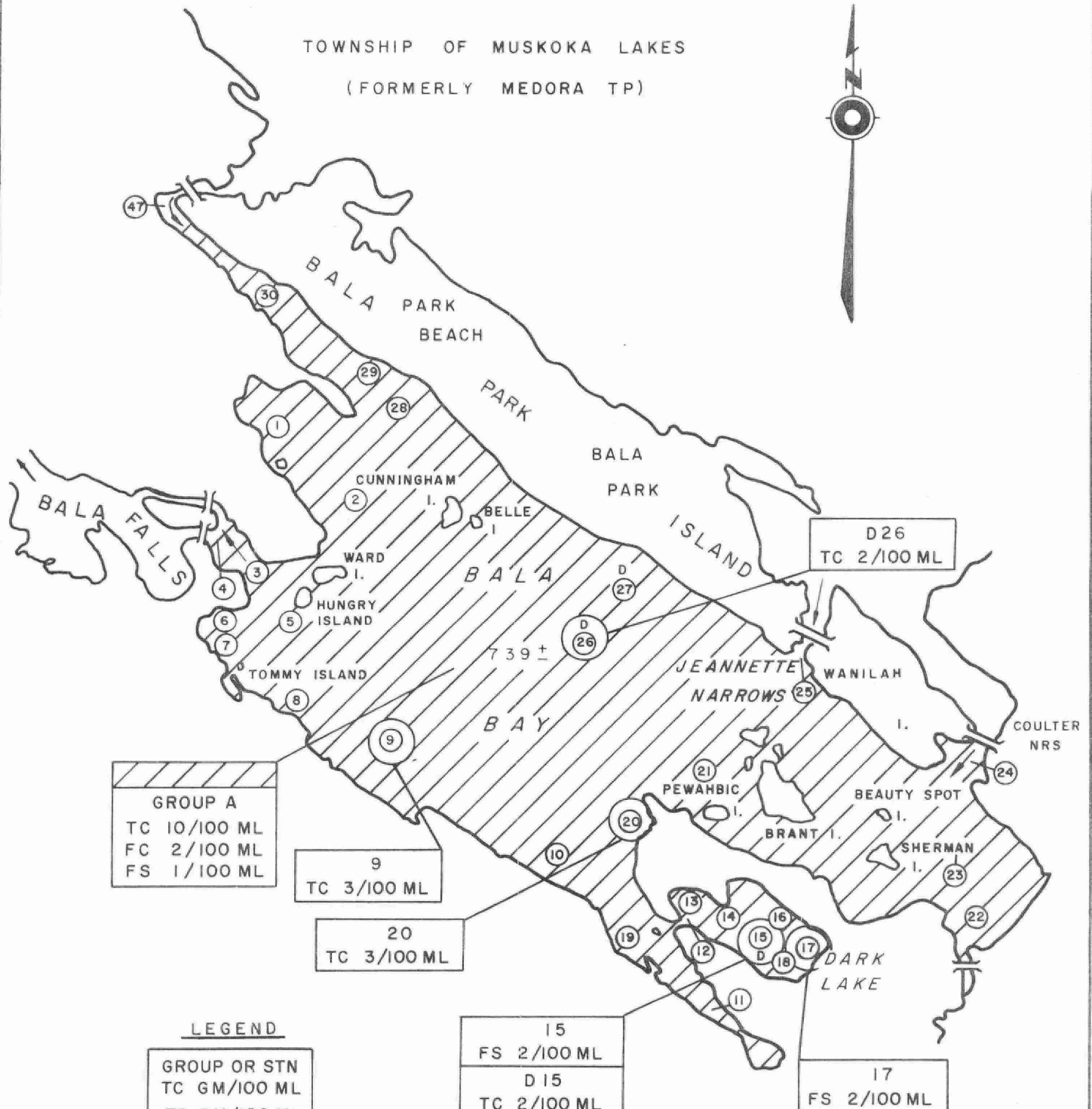
During the August survey, bacterial concentrations were uniformly low with overall geometric means of 20 TC/100 ml, 2 FC/100 ml and 3 FS/100 ml (Tables 4, 5, 6, Figure 5).

In the October survey, Dark Lake and Bala Bay had overall FC and FS levels of 1/100 ml and 2/100 ml respectively, except for Group D (stations 1 and 2) adjacent to the Town of Bala which had statistically higher FC concentrations of 3/100 ml (Figure 6, Tables 5 and 6). The higher FC level coupled with a significantly higher TC level at station 1 (94 TC/100 ml) indicated a bacterial input from the Community of Bala. However, these counts are well within the criteria of 1000 TC/100 ml for recreational use. Group B, in Dark Lake, with 32 TC/100 ml was similar to Group A (24 TC/100 ml). Group C at the outflow of

FIGURE 4

MAY SURVEY

TOWNSHIP OF MUSKOKA LAKES
(FORMERLY MEDORA TP)



LEGEND

GROUP OR STN
TC GM/100 ML
FC GM/100 ML
FS GM/100 ML

(26) — BACTERIOLOGICAL STATION

D — DEPTH STATION

STATUTE MILES

1/2 1/4 0 1 MILE

ONTARIO WATER RESOURCES COMMISSION

RECREATIONAL LAKES PROGRAM

BALA BAY & DARK LAKE

1971 WATER QUALITY SURVEY

SCALE: AS SHOWN

DRAWN BY: R.S.

DATE: MARCH 1972

CHECKED BY:

DRAWING NO: 72-22-D.E.A

AUGUST SURVEY

TOWNSHIP OF MUSKOKA LAKES
(FORMERLY MEDORA TP)



GROUP A	
TC	20/100 ML
FC	2/100 ML
FS	3/100 ML

LEGEND

GROUP OR STN	
TC	GM/100 ML
FC	GM/100 ML
FS	GM/100 ML

- (26) — BACTERIOLOGICAL STATION
D — DEPTH STATION

STATUTE MILES



ONTARIO WATER RESOURCES COMMISSION

RECREATIONAL LAKES PROGRAM

BALA BAY & DARK LAKE

1971 WATER QUALITY SURVEY

SCALE: AS SHOWN

DRAWN BY: R.S.

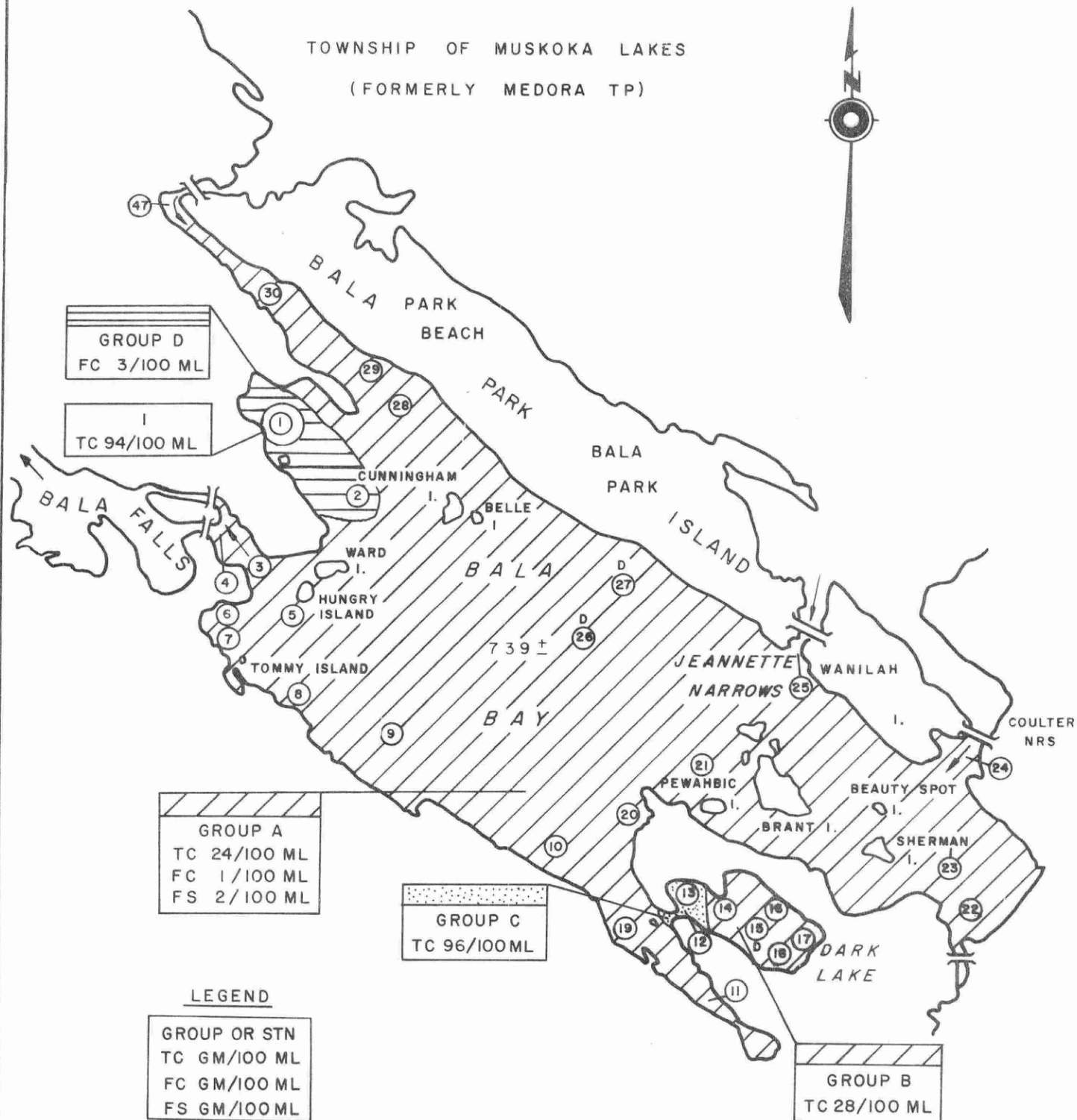
DATE: MARCH 1972

CHECKED BY:

DRAWING NO: 72-22-D.E.A

OCTOBER SURVEY

TOWNSHIP OF MUSKOKA LAKES
(FORMERLY MEDORA TP)



ONTARIO WATER RESOURCES COMMISSION

RECREATIONAL LAKES PROGRAM

BALA BAY & DARK LAKE

1971 WATER QUALITY SURVEY

SCALE: AS SHOWN

DRAWN BY: R.S.

DATE: MARCH 1972

CHECKED BY:

DRAWING NO: 72-22-D.E.A

heavily developed Dark Lake had significantly higher TC counts of 96/100 ml. Station 23 located in Bala Bay had a very low TC geometric mean of 9/100 ml.

Dark Lake and Bala Bay were acceptable for recreational use during all three surveys, however, for domestic use, all surface water should receive treatment including disinfection especially in those areas around the Community of Bala and the outflow from Dark Lake.

TABLE 1

Chlorophyll a and Secchi disc values for Station 15 (Dark Lake) and Station 9 (Bala Bay) during 1971.

	STATION 15		STATION 9	
	CHLOR. <u>a</u>	S.D.	CHLOR. <u>a</u>	S.D.
May 21	0.9 µg/l	4.5m	0.9 µg/l	3.0m
May 22	1.1	-	1.3	-
May 23	1.3	4.5	0.8	3.0
May 24	1.4	4.5	1.3	3.0
May 25	2.0	4.5	1.6	3.0
Aug. 26	3.3	5.0	1.1	5.0
Aug. 27	3.2	5.0	1.4	5.0
Aug. 28	3.6	5.0	1.4	5.0
Aug. 29	3.7	4.0	1.7	5.0
Aug. 30	4.6	4.0	1.9	5.0
Oct. 11	3.7	4.5	2.3	4.5
Oct. 12	3.2	4.5	2.0	4.5
Oct. 13	3.2	4.5	1.9	4.4
Oct. 14	2.8	4.5	1.9	4.5
MEAN	2.92	4.54	1.65	4.22

CHLOR. a = Chlorophyll a
 S.D. = Secchi Disc
 µg/l = Micrograms per litre
 m = metre

TABLE 2

The Araphidinae/Centrales ratio of the surface sediment samples collected from Bala Bay, Station 9 and Dark Lake, Station 15. The samples were collected in triplicate during the autumn of 1971 and three separate analyses were performed on each core sample.

	CORE			CORE			CORE		
	A1	A2	A3	B1	B2	B3	C1	C2	C3
Station #9									
A/C Ratio	0.64	1.09	0.77	1.05	0.80	0.74	0.60	0.26	0.38
Mean A/C Ratio		0.833			0.863			0.413	
Station #15									
A/C Ratio	0.49	0.38	0.56	0.40	0.48	0.41	0.34	0.70	0.42
Mean A/C Ratio		0.477			0.430			0.487	

TABLE 3

Iron, Hardness (Hard), Total Phosphorus (P), Kjeldahl Nitrogen (N), Chloride (Cl) and Conductivity (Cond.) for Dark Lake (Station 15) and Bala Bay, 1971. The results are expressed as mg/l except conductivity which is umho/cm³.

Station	Depth	Date	Iron	Hard	P	N	Cl	Cond
15	1m	24/5	0.20	15	0.018	0.26	4	-
15	1m	25/5	0.10	16	0.018	0.29	4	-
15	4m comp	30/8	0.05	14	0.017	0.19	4	43
15	9m comp	10/10	0.05	14	0.006	0.26	3	43
9	1m	23/5	2.1	14	0.13	0.84	2	-
9	1m	24/5	0.40	14	0.024	0.31	2	-
9	1m	25/5	0.25	14	0.020	0.32	2	-
4	1m	30/8	0.05	13	0.008	0.26	2	41
9	10m comp	30/8	0.05	13	0.010	0.27	3	41
12	1m	30/8	0.05	14	0.012	0.20	3	43
22	1m	30/8	0.05	14	0.008	0.19	3	42
24	1m	30/8	0.05	14	0.010	0.28	3	42
25	1m	30/8	0.05	14	0.008	0.26	3	42
30	1m	30/8	0.05	14	0.021	0.38	3	41
4	1m	10/10	0.05	14	0.010	0.29	2	40
9	9m comp	10/10	0.05	14	0.010	0.29	2	41
24	1m	10/10	0.05	14	0.014	0.26	3	41
25	1m	10/10	0.05	14	0.024	0.27	2	40

EXPLANATION OF TERMS IN BACTERIOLOGICAL TABLES

- F - the calculated analysis of variance statistic on F ratio.
- df - degrees of freedom of the F ratio for "between group" and "within group" variation.
- F(5%) - the F ratio from a statistics table (Rohlf 1969). If the calculated F is greater than the F(5%), a significant difference (SD) occurred between the groups in the analysis. If the F is less than F(5%), no significant difference (NSD) occurred.
- log GM - the logarithm (base 10) of the geometric mean.
- S.E. - the standard error of the log GM where
- $$S.E. = \frac{s}{\sqrt{n}} \text{ and } s = \text{standard deviation}$$

$$\sqrt{\frac{s^2}{n}}$$

- N - the number of values in the mean.
- GM - the geometric mean of the bacterial level.
- t - the calculated test of significance or student t-test used to compare stations, groups and a survey.
- If t for the number of degrees of freedom shown is greater than the critical t value, a significant difference (SD) occurs.
- SD refers to a significant difference at the .05 level but no significant difference at the .01 level.
- SD* refers to a significant difference at the .01 level but no significant difference at the .001 level.
- SD** refers to a significant difference at the .001 level.

TABLE 4

SUMMARY OF THE ANALYSIS OF VARIANCE GROUPING OF STATIONS

PARAMETER: Total Coliform (TC)/100 ml

Survey	May 21 - 25, 1971	August 26 - 30, 1971	October 10 - 14, 1971
Group	All Stations	All Stations	All Stations
F	1.998	0.650	1.708
df	32, 117	32, 98	32, 116
F(.05)	1.551	1.568	1.552
	SD	NSD	SD
Group	A	A	A
	All stations except 9, 15D, 20, 26D	All stations	All stations except 12-18, 1, 15D, 23
F	1.135	0.650	1.344
df	28, 103	32, 98	22, 81
F(.05)	1.592	1.568	1.679
	NSD	NSD	NSD
Log GM	1.0176	1.2942	1.3760
SE	0.0419	0.0613	0.0373
N	132	131	104
GM	10	20	24
Group	-	-	B
			Stations 14 - 18, 15D
F			0.680
df			5, 22
F(.05)			2.661
			NSD
Log GM			1.5152
SE			0.1053
N			28
GM			32
Group	-	-	C
			Station 12 and 13
t			0.0709
df			6.
t(.05)			2.447
			NSD
Log GM			1.9840
SE			0.0699
			8
GM			96

TABLE 5

Summary of Analysis of Variance Grouping of Stations

Parameter: Fecal Coliform (FC)/100 ml

<u>Survey</u>	<u>May 21 - 25, 1971</u>	<u>August 26 - 30, 1971</u>	<u>October 10 - 14, 1971</u>
Group	All Stations	All Stations	All Stations
F	0.598	1.188	1.859
df	32, 121	32, 106	32, 116
F(.05)	1.548	1.560	1.552
	NSD	NSD	SD
Group	A	A	A
	All stations	All stations	All stations except 1 and 2
F	0.598	1.188	1.375
df	32, 121	32, 106	29, 106
F(.05)	1.548	1.560	1.581
	NSD	NSD	NSD
Log GM	0.2104	0.2081	0.117
SE	0.0457	0.0225	0.0172
N	154	136	136
GM	2	2	1
Group	-	-	D
			Station 1 and 2
t			0.325
df			6
t(.05)			2.447
			NSD
Log GM			0.5233
SE			0.1367
N			8
GM			3

TABLE 6

Summary of Analysis of Variance Grouping of Stations

Parameter: Fecal Streptococcus (Enterococcus)(FS)/100 ml

<u>Survey</u>	<u>May 21 - 25, 1971</u>	<u>August 26 - 30, 1971</u>	<u>October 10 - 14, 1971</u>
Group	All Stations	All Stations	All Stations
F	1.655	0.700	0.765
df	32, 130	32, 103	32, 116
F(.05)	1.542	1.552	1.552
	SD	NSD	NSD
Group	A	A	A
	All stations except 15 and 17	All stations	All stations
F	1.467	0.700	0.765
df	30, 122	32, 103	32, 116
F(.05)	1.552	1.55	1.552
	NSD	NSD	NSD
Log GM	0.0472	0.4593	0.2062
SE	0.0105	0.0464	0.0298
N	153	136	149
GM	1	3	2

GLOSSARY OF TERMS

ALKALINITY	:The alkalinity of a water sample is a measure of its capacity to neutralize acids. This capacity is due to carbonate, bicarbonate and hydrozide ions and is arbitrarily expressed as if all of the neutralizing capacity was due to calcium carbonate alone.
ANOXIC	:Refers to conditions when no oxygen is present.
BACKGROUND COLONIES	:Background colonies are other lake water bacteria capable of growing on the total coliform plate, in spite of the inherent restrictive conditions.
CHLORIDE	:Chloride is simply a measure of the chloride ion concentration and is not a measure of chlorination.
CHLOROPHYLL <u>a</u>	:A green pigment in plants.
CONDUCTIVITY	:Conductivity is a measure of the waters ability to conduct an electric current and is due to the presence of dissolved salts.
DIATOMS	:Unicellulr plants found on all continents and in all types of water where light and nutrients are sufficient to support photosynthesis. They are comprised of two siliceous frustules (cell walls) which have an outer valve (epitheca) fitting over the inner valve (hypotheca) like the lid on a box. The siliceous deposits comprising the frustules vary in regular patterns according to the individual species.
EPILIMNION	:Is the thermally uniform layer of a lake lying above the thermocline. Diagram I.
EUPHOTIC ZONE	:The lighted region that extends vertically from the water surface to the level at which photosynthesis fails to occur due to insufficient light penetration.
EUTROPHIC	:Waters containing advanced nutrient enrichment and characterized by a high rate of organic production.

EUTROPHICATION	:The process of becoming increasingly enriched in nutrients. It refers to the entire complex of changes which accompanies increasing nutrient enrichment. The result is the increased production of dense biological growths such as algae and aquatic weeds which generally degrade water quality and render the lake unsuitable for many recreational activities.
FECAL COLIFORMS (FC)	:Fecal coliforms are bacteria associated with recent fecal pollution from man and animals.
FECAL STREPTOCOCCUS (FS)	:Fecal streptococcus are bacteria associated with fecal pollution from animals and to a lesser extent man.
HARDNESS	:Hardness of water is a measure of the total concentration of calcium and magnesium ions expressed as if all of the ions were calcium carbonate.
HYPOLIMNION	:The uniformly cold and deep layer of a lake lying below the thermocline, when the lake is thermally stratified. Diagram #1
KJELDAHL NITROGEN	:Sum of nitrogen present in the ammonia and organic forms (it does not include nitrite or nitrate).
MESTROPHIC	:Waters characterized by a moderate nutrient supply and organic production (i.e. midway between eutrophic and oligotrophic).
METALIMNION	:See thermocline.
OLIGOTROPHIC	:Waters containing a small nutrient supply and consequently characterized by a low rate of organic production.
pH	:Is the measure of the hydrogen ion concentration expressed as the negative logarithm of the molar concentration.
PHOSPHORUS (TOTAL)	:Sum of all forms of phosphorus present in the sample.

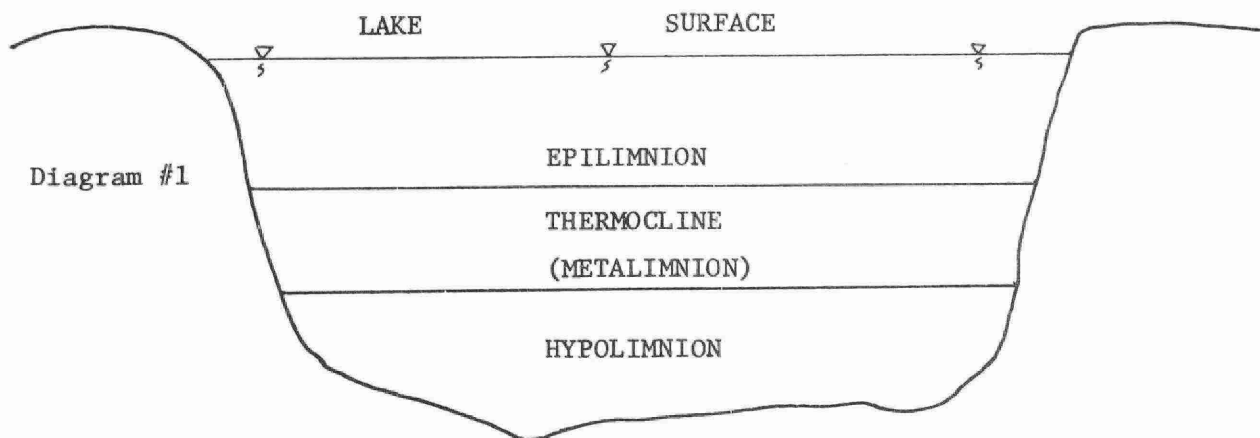
SECCHI DISC

:A circular metal plate, 20 centimeters in diameter, the upper surface of which is divided into four equal quadrants. Two quadrants directly opposite each other are painted black and the intervening ones white. The secchi disc is used to estimate the turbidity of the lake water.

THERMAL STRATIFICATION :During the spring, vertical temperatures in a lake are homogeneous from top to bottom. As summer advances, the surface waters become warmer and less dense than the underlying cooler waters. A strong thermal gradient (Thermocline) occurs giving rise to three distinct water layers. The variation in density between layers retards mixing by wind action and water currents. Diagram #1.

THERMOCLINE (metalimnion)

:The layer of water located between the epilimnion and hypolimnion in which the temperature exhibits a decline equal to or exceeding 1°C increase per meter.



TOTAL COLIFORMS (TC) :Total coliforms are bacteria commonly associated with fecal pollution but may also be present naturally in the environment.

TROPHIC STATUS :Depending upon the degree of nutrient enrichment and resulting biological productivity, lakes are classified into three intergrading types:

TROPHIC STATUS
(continued)

:oligotrophic, mesotrophic and eutrophic.

If the supply of nutrients to an oligotrophic lake is progressively increased, the lake will become more mesotrophic in character and with continued enrichment it will become eutrophic.

BIBLIOGRAPHY

- BENNETT, E.A. Taken from the Great Lakes as an Environment,
Edited by D.V. Anderson, Great Lakes Institute
Report PR 39, University of Toronto, October 1969.
- BROWN, D.J. 1972 Chlorophyll a - Secchi disc relationship
in Ontario Recreational Lakes (In Preparation).
- BURGER, A. Statistical Bacterial Data Summarization and
Interpretation Internal OWRC Report (Unpublished).
- Guidelines and Criteria for Water Quality Management in Ontario,
OWRC, June 1970.
- Microbiological Criteria
Water used for body contact recreational
activities should be free from pathogens
including any bacteria, fungi or viruses that
may produce enteric disorders or eye, ear,
nose, throat and skin infections. Where
ingestion is probable, recreational waters
can be considered impaired when the coliform,
fecal coliform, and/or enterococcus geometric
mean density exceeds 1000, 100 and/or 20
per 100 ml respectively, in a series of at
least 10 samples per month, including samples
collected during weekend periods.
- RICHARDS, F.A. and THOMPSON, T.G. 1952 The estimation and
characterization of plankton populations by pigment
analysis II. The spectrophotometric method for the
estimation of plankton pigments. J. Marine Res., 11:156.
- ROHLF, F.M. and SOKAL, R.R. 1969 Statistical Tables, W.H. Freeman
and Company, San Francisco.
- SOKAL, R.R. and ROHLF, F.J. 1969 Biometry, the principals and
practices of statistics in biological research, W.H.
Freeman and Company, San Francisco.
- Standard Methods for the Examination of Water and Wastewater, 13th
Edition, 1971. APHA, AWWA, WPCF.
- STOCKNER, J.G. 1971 Preliminary characterization of lakes in the
Experimental Lakes Area, Northwestern Ontario, using
diatom occurrences in sediments. J. Fish. Res. Bd.
Canada 28:265-275.